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air navigation

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1951

DEPARTMENT OF THE AIR FORCE

Therefore, within the limits of reasonable DR, the correct GH will be obtained if the same longitude is applied for conversion to grid that was used to obtain LHA.

When steering by the directional gyros in current use (1949), gyro precession necessitates frequent heading checks by astrocompas observations. These heading checks should be spaced about 20 to 40 minutes to insure accurate steering. The TH read from the astrocompass is converted to GH by application of DR longitude in the conversion formula. A GH may be set on the pilot's directional gyro, which is used to turn the aircraft to any desired grid heading.

When very near the pole, the azimuth method of using the astrocompass may be advantageous. For an observer at the North Pole, the G-azimuth (GZ) of a body equals GHA plus or minus 180°. This relationship is true not only at the pole but anywhere on the meridian which passes through the subpoint of the body. Therefore, in selecting a body for use in steering a course, it is advantageous to choose one whose location is such that the DR position is close to this meridian. Actually, if the body being observed has an altitude of less than 30°, the DR position may be 100 n.m. removed from the meridian through the subpoint without introducing an error greater than 1° in the azimuth computed.

For the azimuth method, the astrocompass is set with the latitude scale at 90° and altitude of the body on the declination scale. Then GZ = (GHA + or − 180°) is placed on the white LHA scale at the true-bearing index.

The GH is then read against the true-heading index.

If the DR position of the aircraft is not close to the meridian of the body, error will result from the assumption that GZ = GHA + or − 180°. In such a case, the azimuth method, or relative bearing method, requires a tabular solution for azimuth.

CELESTIAL SOLUTIONS IN POLAR NAVIGATION

At either of the poles of the earth, the zenith and the elevated pole are coincident, and the plane of the horizon is coincident with the plane of the equator. Vertical circles coincide with meridians, and parallels of latitude coincide with declination circles. Therefore, the altitude of the body is equal to its declination, and azimuth angle is equal to hour angle.

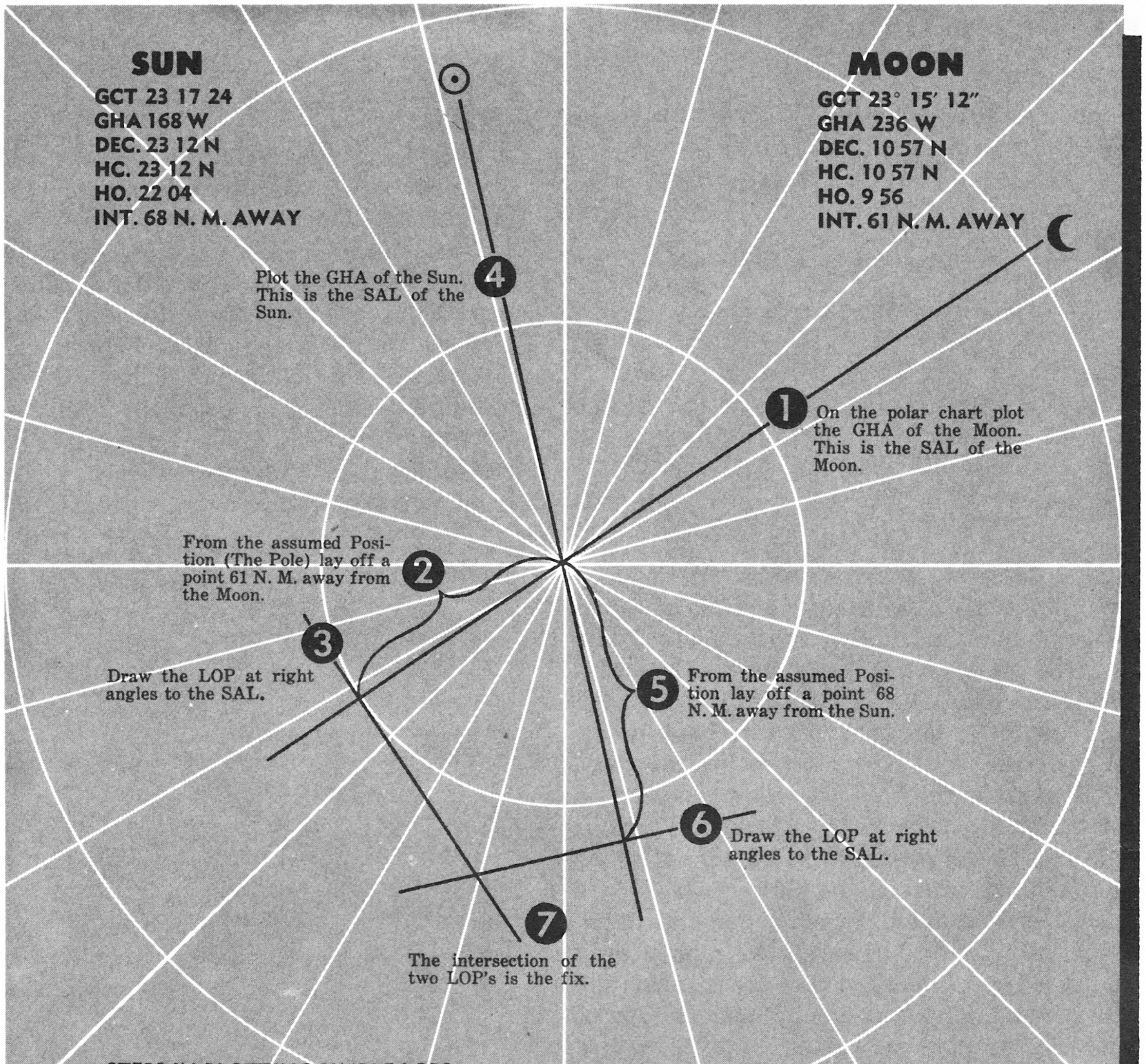
At the North Pole, as was noted previously, GZ = GHA + 180°. Therefore, azimuth lines may be plotted directly from the GHA. The GHA is measured from the upper branch of the Greenwich meridian (GHA + 180° from the **lower** branch) and the azimuth line thus determined is known as the *star azimuth line* (SAL).

SIMPLE LOPS AND FIXES IN POLAR NAVIGATION

To plot any LOP, an assumed position, an intercept, and the azimuth of the body, are needed. In the polar solution, the elevated pole is the assumed position. The azimuth line is the SAL, which is plotted as the GHA of the body, or the longitude of its subpoint. The intercept is found by comparing the declination of the body, as taken from the Almanac, with the observed altitude of the body.

Thus, at the pole or when the pole is taken as the assumed position, declination = Hc, and GHA = SAL. Therefore, no tabulated solution of the celestial triangle is necessary; the Almanac gives the information needed.

When a celestial body is observed, the exact GCT should be noted. From the Almanac is found the proper declination (Hc) and GHA (SAL). The SAL is plotted. Ho and Hc are compared to obtain the intercept. When the observed altitude, Ho, is greater



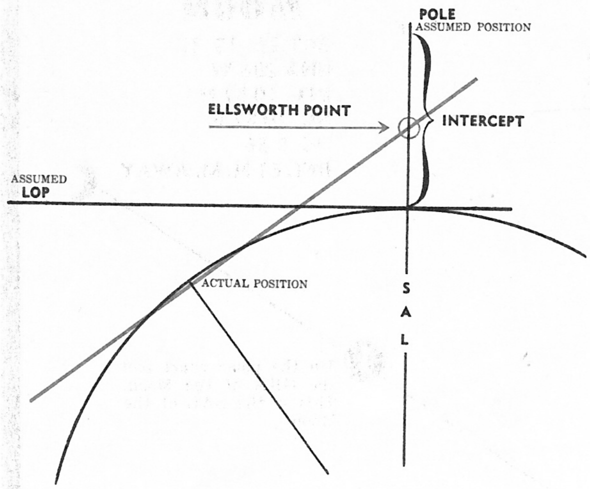
STEPS IN PLOTTING SIMPLE LOPS

than the declination, Hc, it is necessary to go from the pole **toward** the celestial body along the SAL. If the observed altitude is less than the declination, it is necessary to go from the pole **away** from the body along the SAL. The LOP's are drawn perpendicular to the azimuth line in the usual manner. It is not necessary to be concerned about large intercepts; they have no bearing upon the accuracy of this type of fix.

Observations on well-separated bearings give a fix that is as good close to the poles as it is anywhere else. For example: Near the pole, about midnight on 29 June 1940, the Ho of the moon by bubble sextant was 9°01′ at $23^h15^m12^s$ GCT, and the Ho of the sun was 22°04′ at $23^h17^m24^s$ GCT.

In the foregoing example, the actual position was within 100 miles of the SAL. This makes unnecessary any further corrections. If the DR position is more than 100 miles from the SAL, this method of simple fixes will not give accurate results. This is true because the circle of equal altitude will curve an appreciable distance away from the tangent line if the LOP is long. Also, the azimuth at the DR position would not be the same as that represented by the SAL.

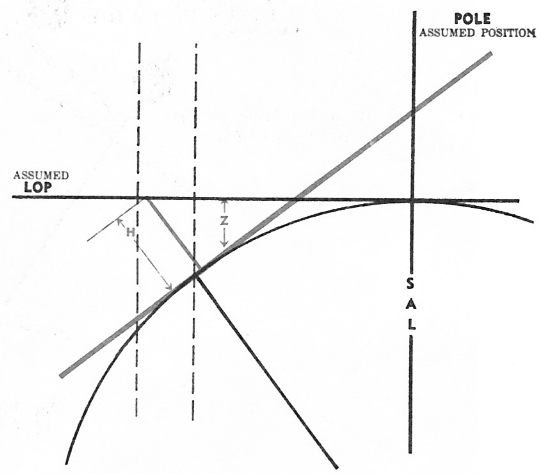
ELLSWORTH FIXES



If a tangent is drawn through the aircraft's actual position on the circle of equal altitude, and this line is extended to intersect the SAL, two facts appear: (1) the intersection upon the SAL is away from both the body and the original intercept point, and (2) the LOP no longer makes an exact right angle with the SAL. The new point of intersection is termed the *Ellsworth point.*

It can be shown that the change of angle and distance between the intercept point and the Ellsworth point is unique for any particular DR position. These values have been computed and tabulated, and the result is the *Ellsworth table.* The amount and degree of these corrections are dependent upon two things: (1) the distance of the actual position from the SAL, and (2) the steepness of the curve of equal altitude which, in turn, is determined by the altitude of the body observed.

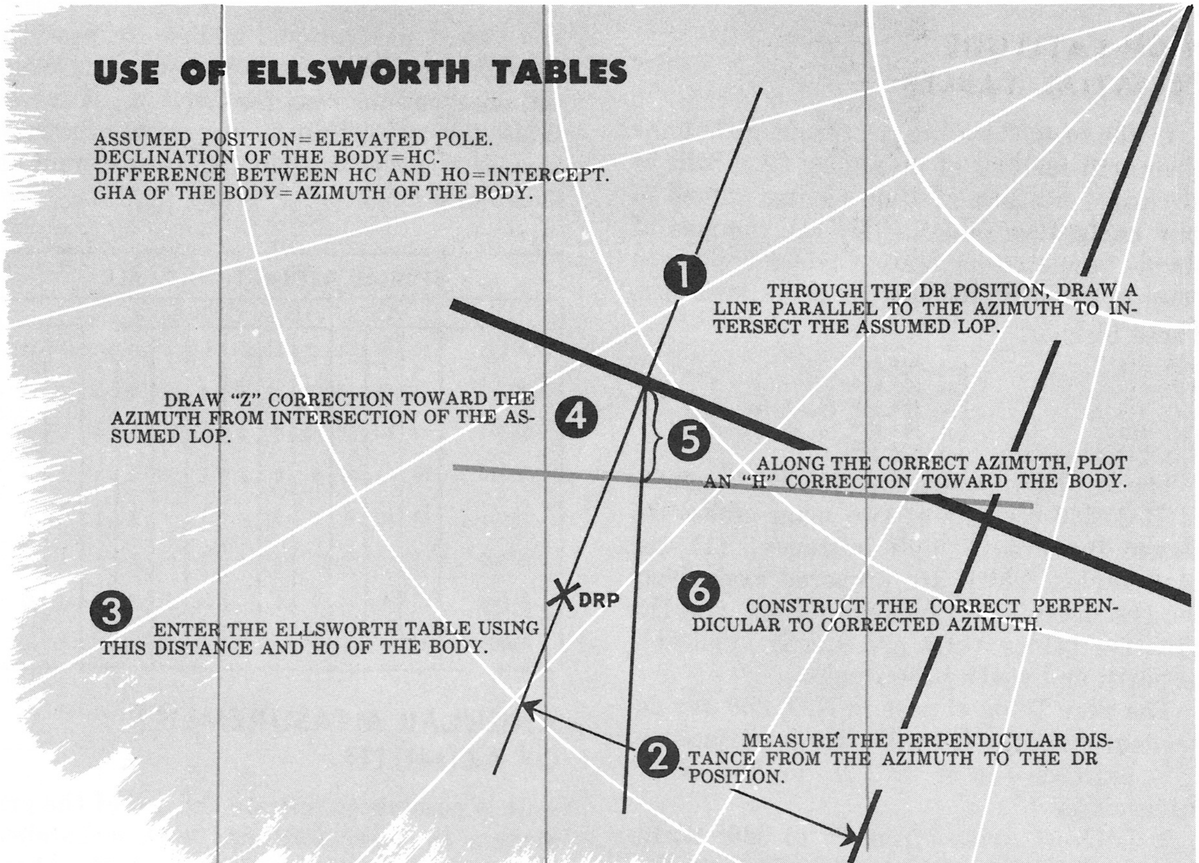
Therefore, the entering arguments for the Ellsworth correction tables are: (1) distance of the DR position from the SAL, and (2) the observed altitude of the body. With these values, the table is entered, and two corrections are extracted: (1) an H-correction which gives the distance between the intercept point and the Ellsworth point, measured from the intercept point away from the body, and (2) a Z-correction which is the angular difference between a perpendicular to the SAL and the desired LOP.

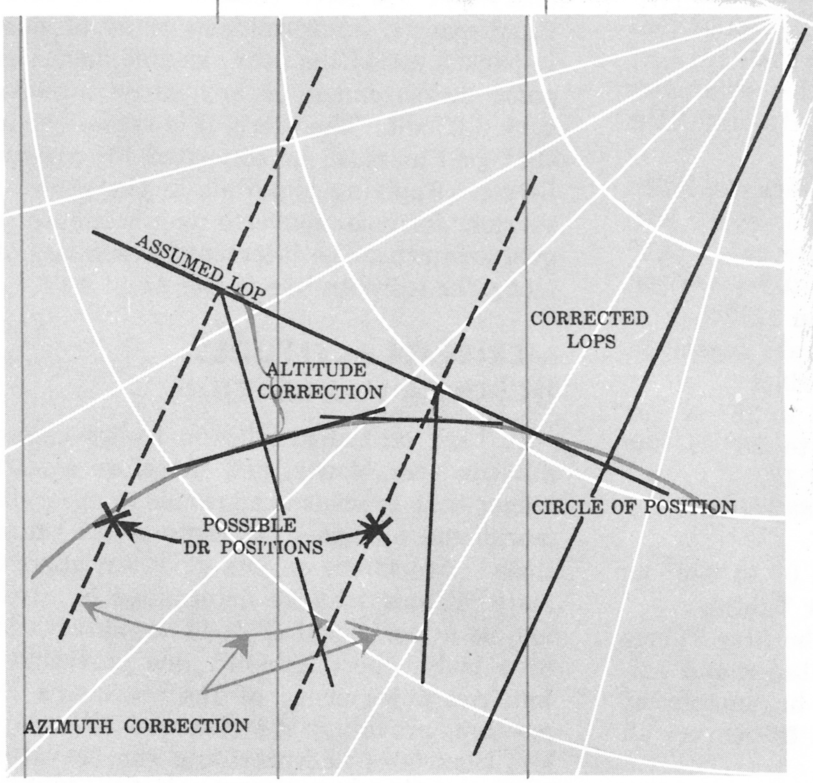


ELLSWORTH TABLE

Ho	10°		15°		20°		25°		30°		35°		40°		45°		50°	
Distance	H′	Z°	H′	Z°	H′	Z°	H′	Z°	H′	Z°	H′	Z°	H′	Z°	H′	Z°	H′	Z°
100	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.8	1.0	1.0	1.2	1.2	1.4	1.4	1.7	1.7	2.0
200	1.1	0.6	1.6	0.9	2.2	1.2	2.7	1.6	3.4	1.9	4.0	2.3	5.0	2.8	5.0	3.3	7.0	4.0
300	2.1	0.9	3.5	1.4	4.8	1.8	6.1	2.3	7.6	2.9	9.2	3.5	11	4.2	13	5.0	16	5.9
400	4.1	1.2	6.2	1.8	8.5	2.4	11	3.1	13	3.8	16	4.6	20	5.6	23	6.6	28	7.9
500	6.2	1.4	9.7	2.2	13	3.0	17	3.9	21	4.8	25	5.8	30	6.9	36	8.2	43	9.8
550	7.8	1.6	12	2.4	16	3.3	20	4.2	25	5.2	31	6.4	37	7.6	44	9.1	52	11
600	9.2	1.8	14	2.7	19	3.6	24	4.6	30	5.7	37	6.9	44	8.3	52	9.8	62	12
650	11	1.9	16	2.9	22	3.9	28	5.0	35	6.2	43	7.5	51	9.0	61	11	72	13
700	13	2.0	19	3.1	26	4.2	33	5.4	41	6.7	50	8.1	59	9.6	70	11	84	14
750	14	2.2	22	3.3	30	4.5	38	5.8	47	7.1	57	8.6	68	10	81	12	96	14
800	16	2.3	25	3.5	34	4.8	43	6.1	53	7.6	65	9.2	77	11	92	13	109	15
850	18	2.5	28	3.8	38	5.0	49	6.5	60	8.0	73	9.7	87	12	103	14	122	16
900	21	2.6	32	4.0	43	5.4	54	6.9	67	8.5	81	10	97	12	115	15	136	17

USE OF ELLSWORTH TABLES





ELLSWORTH TABLES MAY BE USED ANYWHERE WITHIN TEN TO TWELVE DEGREES OF THE POLE, EVEN WHEN YOUR EXACT POSITION IS IN DOUBT, NO MATTER HOW FAR YOUR DR POSITION MAY BE IN ERROR, THE ELLSWORTH CORRECTIONS WILL PRODUCE LOP'S TANGENT TO THE TRUE CIRCLE OF EQUAL ALTITUDE AND THEREBY NULLIFY ANY ERROR OF ASSUMED POSITION.